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THE COMPOSITION, ORIGIN, AND RELATIONSHIPS OF THE CORNIFEROUS FAUNA IN THE APPALACHIAN PROVINCE OF NORTH AMERICA.

THE Devonian was pre-eminently a period of provincial development of marine faunas. In the Appalachian Province of North America, lying to the west of the ancient Appalachian land and to the east of the Wisconsin-Ozark land, there were introduced successively, with little or no foreshadowing, the Helderbergian, Oriskany, Corniferous, Hamilton, and Upper Devonian faunas. Each of these faunas possesses characteristics peculiar to itself which could not have been derived from the next preceding fauna, but which must have been in process of evolution during a long period of time in some other region of the earth. It is perhaps not too much to assume that each of these faunas had its ultimate origin from the earlier, more cosmopolitan fauna of Silurian time, and that their evolutions were in progress contemporaneously, each in its own more or less isolated province. Their succession, therefore, in the Appalachian Province may be entirely accidental rather than genetic.

The amount of faunal change initiated with the introduction of these various faunas differs greatly in degree. In the case of the Hamilton fauna, there are a large number of species which are common also to the preceding Corniferous fauna; in fact, the great majority of the members of the Hamilton fauna are a residuum or an evolution product from the Corniferous fauna. The number of strange forms[1] introduced is small, but they are of such a nature as to show the presence at this time of a means of communication between the Appalachian province and a southern hemisphere province, probably in South America. The presence of these forms, with the internal changes which were in progress, serves to give a character to the Hamilton fauna which is unmistakable.

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[1] The chief of these exotic Hamilton species are *Tropidoleptus carinatus* Con., *Vitulina pustulosa* H., and *Chonetes coronatus* Con.

The faunal change at the opening of the Upper Devonian was far more profound than that which initiated the Hamilton, and it has been shown by Williams,[1] that the foreign element in these faunas, initiated in the Cuboides fauna of the Tully limestone in New York, had its origin in the Middle Devonian faunas of the Eurasian province, and that it found its way into the Appalachian province by way of the Mackenzie Valley of Northwestern Canada, southeastwardly through Manitoba and Iowa.

The life changes introduced with the Corniferous fauna were perhaps even more profound than the changes which took place with the introduction of the Eurasian faunas at the opening of Upper Devonian time. The Corniferous fauna is a large and varied one, and is one of the most widespread of the Devonian faunas of the Appalachian province. Strata containing the fauna are present in New York, where the formation is known as the Onondaga limestone. In Ohio the fauna occurs in the Columbus limestone, and in southern Indiana and Kentucky in the Jeffersonville limestone. The fauna occurs also in southern Illinois near Grand Tower, and reaches as far to the north as northern Michigan. It occurs also in Ontario, to the north of Lake Erie. The fauna has its best development in the central portion of the province, especially in central Ohio and in the neighborhood of the falls of the Ohio River.

The most comprehensive list of invertebrate species occurring in the fauna in the central portion of the province is that which has been published by Whitfield[2] for the region about Columbus, O. It does not, perhaps, contain the names of all members of the fauna as it occurs throughout the entire province, but it is a representative list, and will serve the purpose of making comparison between this fauna and the preceding Oriskany fauna. For a revised list of the vertebrate genera of the fauna I am indebted to Dr. C. R. Eastman, of the Museum of Comparative Zoölogy at Cambridge. The list of

[1] *Bull. Geol. Soc. Am.*, Vol. I, p. 481.

[2] *Geol. Surv. Ohio*, Vol. VII, pp. 434–40.

Oriskany species used for comparison with the Corniferous fauna is the one prepared by Schuchert.[1] In this Oriskany list, however, the forms occurring only at Cayuga, Ontario, have been eliminated, for reasons that will appear later, as they cannot be considered as being members of the pure Oriskany fauna. In both the lists some changes in nomenclature have been made, in accordance with recent usage. Only the genera are recorded, the number following each generic name indicating the number of species.

COMPARATIVE LISTS OF THE CORNIFEROUS AND ORISKANY FAUNAS.

CORNIFEROUS.		ORISKANY.	
PORIFERA.			
Receptaculites	1		
HYDROZOA.			
Stromatopora	5		
Cannopora	2		
ANTHOZOA.		ANTHOZOA.	
Favosites	7	Favosites	2
Michelinia	2		
Emmonsia	1		
Trychopora	1		
Aulopora	3		
Syringopora	3		
Eridophyllum	3		
Stylastrea	1		
Zaphrentis	5		
Cyathophyllum	2		
Hadriophyllum	1		
Heliophyllum	2		
Aulocophyllum	1		
Cystiphyllum	2		
ECHINODERMATA.		ECHINODERMATA.	
Megistocrinus	1	Homocrinus	1
Dolatocrinus	2	Mariacrinus	4
Nucleocrinus	1	Edriocrinus	1
Codaster	1	Anomalocystites	1
Ancyrocrinus	1		

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[1] *Ann. Rept. N. Y. State Geol.*, for 1888, pp. 52–54.

Bryozoa.			
Stictopora	1		
Lichenalia	1		
Brachiopoda.		Brachiopoda.	
Orbiculoidea	1	Orbiculoidea	1
Crania	2	Pholidops	2
Rhipidomella	2	Rhipidomella	2
Schizophoria	1	Dalmanella	1
Orthothetes	2	Anoplia	1
Stropheodonta	6	Stropheodonta	4
Strophonella	1	Strophonella	1
Leptaena	1	Leptaena	1
Pholidostrophia	1	Hipparionyx	1
Chonetes	5	Chonostrophia	1
Productella	1	Metaplasia	1
Spirifer	12	Spirifer	6
Reticularia	1	Reticularia	1
Cyrtina	1	Cyrtina	1
Meristella	2	Meristella	4
Nucleospira	1	Rhynchospira	1
Atrypa	1	Anoplotheca	3
Camarotoechia	4	Camarotoechia	2
Rhynchonella	1	Rhynchonella	6
Pentamerella	1	Eatonia	4
Eunella	1	Rensselaeria	4
		Megalanteris	1
		Beachia	1
Pelecypoda.		Pelecypoda.	
Aviculopecten	2	Avicula	3
Pterinea	1	Megambonia	2
Mytilarca	2		
Conocardium	1		
Goniophora	1		
Paracyclus	2		
Modiomorpha	2		
Sanguinolites	1		
Gasteropoda.		Gasteropoda.	
Platyceras	7	Platyceras	10
Platyostoma	1	Strophostylus	4
Euomphalus	1	Cyrtolites ?	1
Turbo	2		
Isonema	3		

Gasteropoda.—*Continued.*			
Xenophora	1		
Naticopsis	3		
Loxonema	4		
Orthonema	1		
Macrocheilus	1		
Pleurotomaria	4		
Murchisonia	3		
Dentalium	1		
Bellerophon	3		
Pteropoda.		Pteropoda.	
Conularia	1	Conularia	1
Tentaculites	1	Tentaculites	1
Cephalopoda.		Cephalopoda.	
Orthoceras	3	Orthoceras	1
Trematoceras	1		
Gomphoceras	4		
Cyrtoceras	3		
Gyroceras	5		
Trilobita.		Trilobita.	
Dalmanites	3	Homalonatus	2
Phacops	1		
Proetus	1		
Vertebrata.			
Acanthaspis.			
Acantholepis.			
Asterosteus.			
Cladodus.			
Coccosteus.			
Cyrtacanthus.			
Dinichthys.			
Dipterus.			
Machaeracanthus.			
Macropetalichthys.			
Onychodus.			
Palaeomylus.			
Ptyctodus.			
Rhynchodus.			

The conspicuous elements in the Corniferous fauna, when compared with the Oriskany, are the great abundance of corals and the large number of fishes. There is also a very much larger representation of mollusks in the Corniferous fauna; and even among the brachiopoda, where the two faunas have a greater similarity than elsewhere, they are conspicuously different, especially by reason of the absence from the later fauna of genera which were conspicuous in the earlier one. Corals were practically absent from the Oriskany fauna, but in the Corniferous they are everywhere present, usually in abundance, and in some portions of the province they must have grown in great coral reefs. The cephalopods are among the rarest of fossils in the Oriskany fauna, but in the Corniferous there are many of them, often of large size, among which are present straight, curved, and closely coiled forms. Both in its coral element and in its cephalopod element, as well as in the remaining mollusks, there is a strong suggestion in the Corniferous of a recurrence, with profound modifications to be sure, of the more ancient Niagaran fauna, which had occupied the same province at an earlier period. It is altogether probable that the Corniferous fauna was in large part truly an evolution product from the Niagaran, after that fauna had withdrawn from the interior and had become isolated in some province upon the border of the continent after the close of Silurian time.

In its geographic distribution the Corniferous fauna is practically limited to the Appalachian basin in all directions except to the north. The fauna is not known to occur to the east or south of the Appalachian land, which formed the barrier to the interior basin in those directions. Neither does it extend beyond the Wisconsin-Ozark barrier, which was the western boundary of the basin. To the north, however, the fauna occurs beyond the interior province, in the Hudson's Bay basin, which then, as now, was probably connected with the Arctic basin. In a "provisional list of fossils collected between the Long Portage of the Missinaibi branch of the Moose River and Moose Factory," Whiteaves[1] has recorded a list of thirty-three species. Among these are some thirteen corals belonging to genera and species which occur commonly in the Corniferous fauna of the Appala-

[1] *Geol. Surv. Canada*, "Rept. of Prog. 1877-8," p. 50.

chian province, and the associated species are such as to leave no doubt in regard to the entire fauna being a representative of the Corniferous fauna of the interior basin. In another place, from the same general region, Whiteaves[1] has recorded a fauna of ten species with the following remark:

> The fossils described or mentioned above show clearly that the rocks from which they were collected are of Devonian age, also that they belong to the horizon of the Corniferous limestone.

Of these ten species, six are corals, and one, *Macropetalichthys sullivanti*, is one of the most characteristic of the fishes found in the fauna in Ohio.

The Devonian faunas of the Arctic region are practically unknown, but two genera of the Corniferous fishes of the Appalachian province, *Acanthaspis* and *Onychodus*, are known to occur in the Devonian strata of Spitzbergen.[2] Nine of the total thirteen genera are also known from the middle Devonian of the Eifel region of Germany, and three from Bohemia. Many of the invertebrate members of the Corniferous fauna also have representatives in the middle Devonian faunas of central Europe.

From the geographic distribution of the Corniferous fauna, it may be suggested that the province in which it originated was situated somewhere in the Arctic regions, and that representatives of it migrated southward both into North America and into Europe. It has been suggested elsewhere[3] that the typical Niagaran fauna, as it exists in the Appalachian province, came into the region from the north through the junction of the Hudson's Bay basin with the interior basin, and, when it withdrew from the interior, it doubtless followed the same route by which it had entered. During the period of disturbance or readjustment between Silurian and Devonian time it is not improbable that the restricted Niagaran fauna became isolated in the Arctic region, and that from the elements of this fauna, during a long period of time, the Corniferous fauna evolved. This hypothesis, however, does not account for the remarkable vertebrate element in the Corniferous fauna, as there was nothing in the Niagaran fauna which could have given origin to it. It is possible that the fishes of the Corniferous fauna originated from some fresh water fish fauna which was forced to adapt itself to marine conditions with the encroachment of the Corniferous sea upon the land. During the Corniferous epoch, in the Appalachian province, communication was again established over the same route by which the Niagaran faunas had found their way into the interior basin.

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[1] *Geol. Surv. Canada*, "Rept. of Prog., 1875–76," pp. 316–20.

[2] Private communication from Dr. C. R. Eastman.

[3] JOUR. GEOL., Vol. VII, p. 692.

The relationship of the Corniferous to the Oriskany fauna at Cayuga, Ontario, also bears upon the point of entrance of the Corniferous fauna into the Appalachian basin. This locality is approximately the most northwestern extension of the typical Oriskany fauna, and is where it approaches most closely to the hypothetical point of entrance of the younger fauna. Here the two faunas become intimately commingled, a large number of the typical corals, besides other Corniferous types, being associated with such characteristic Oriskany species as *Spirifer arenosus*, *Hipparionyx proximus*, *Anoplotheca flabellites*, etc., as if it were here that the Corniferous fauna first came in contact with the Oriskany. It is because of this relationship that the species found in the Oriskany fauna only at Cayuga, and not further east, have been eliminated from the preceding list of Oriskany species given for comparison with the Corniferous fauna, it being assumed that they were not members of the true Oriskany fauna, but were representatives of the immigrating Corniferous fauna.

In the Devonian faunas of the Eureka District of Nevada,[1] many representatives of the Corniferous fauna of the Appalachian province have been recognized. Among these are several of the characteristic corals, although but few of the fish remains have been detected. In the Kanab Cañon of northern Arizona,[2] however, which is situated in the same Great Basin province, a strongly marked horizon of Devonian fishes has been recorded. That the Great Basin province had communication with the original province in which the Corniferous fauna had its development, is quite certain, although there was probably no direct communication between the Great Basin and the Appalachian provinces, notwithstanding the identity of many species in the two regions.

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[1] WALCOTT, *Monog. U. S. Geol. Surv.*, Vol. VIII.

[2] *Monog. U. S. Geol. Surv.*, Vol. VIII, p. 7.

There are also present in the Devonian faunas of the Great Basin province many species which are identical with Hamilton species in the Appalachian province, but they do not occur at any definite horizon in the Devonian of the region, but are distributed from the bottom to the top. Among these species, however, in no case has there been recorded any of the typically southern hemisphere forms which are so characteristic of the Appalachian Hamilton fauna, all of the Hamilton species in the Great Basin Devonian being such as doubtless had their origin from members of the Corniferous fauna, and it is probable that the Great Basin province never had communication with the Southern Hemisphere province which sent its immigrants into the Appalachian province during Hamilton time.

In the Devonian faunas of the Iowan or Northwestern province there is an element so strongly suggestive of the Corniferous that Dr. Barris[1] at one time went so far as to refer some of the Devonian beds of eastern Iowa to the Corniferous. That there is a Corniferous element in these faunas, exhibiting itself especially among the corals, cannot be denied ; but associated with this element, either directly or in accompanying strata, there is another element so entirely foreign to the Corniferous that the reference of any of the Iowan Devonian strata to the Corniferous cannot be entertained. The Eurasian origin of the characteristic element of the Iowan Devonian faunas and of the upper Devonian faunas of the Appalachian province has been established, and the pathway of communication from the Eurasian to the Appalachian province was through the Mackenzie basin of the northwest, which doubtless communicated with the Arctic province where originated the Corniferous fauna. It is not strange, then, that some elements of the Corniferous fauna became mingled with this Eurasian fauna as it migrated toward the Appalachian province. This will account for the presence of a considerable number of species which are common to both the Appalachian Hamilton and the Iowan faunas. In all cases these species are forms such as *Cyrtina hamiltonensis*, *Pholidostrophia iowensis*, *Stropheodonta demissa*, etc., which either were present in the Corniferous fauna, or had their nearest allies in that fauna. In the case of the genus *Schizophoria* we have an example of a form which was well represented in the Cornifersus fauna by the species *S. propinqua*, but which became almost extinct in the Appalachian Hamilton fauna, to be reintroduced into the Appalachian province with the opening of Upper Devonian time by such species as *S. tulliensis* and *S. striatula*.

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[1] *Proc. Davenport Acad. Nat. Sci.*, Vol. II, p. 261.

In the Great Basin province the two Devonian faunas having a definite stratigraphic sequence are first, the fauna with Corniferous affinities in the lower strata of the section, and, second, the Eurasian fauna allied to that of the Iowan and the upper Devonian faunas of the Appalachian provinces. Both of these faunas doubtless entered the region by the same route from a nearly north direction.

The value of any hypothesis proposed for the explanation of natural phenomena must rest upon the number and variety of observed facts for which it offers an explanation. The hypothesis that the Corniferous fauna had its origin in an Arctic province seems to afford an explanation for many facts relative to the geographic distribution and the faunal relationships of some of our Devonian faunas in America, and may thus stand as a working hypothesis which future observations will either strengthen or overthrow.

STUART WELLER.

THE UNIVERSITY OF CHICAGO.